Abstract— Microstrip Patch antenna are very useful in communication system. Microstrip patch antenna are advantages for various applications performances with their low weight, low profile, low cost, made them the perfect and easy to design. Its has some disadvantages such as narrow bandwidth, low gain and directivity to overcome with these issues array is designed. The resonant frequency for proposed design is 3GHz. This proposed design performed in the three frequency band L-band, S-band and C-band at frequencies of 1.9GHz, 3.5GHz and 5.4GHz. The return loss in all three band is more than -10dB. All this three band cover the following GSM, WiMAX, WLAN applications in this proposed geometry designing. Calculations and simulation is performed with Zeland Program manager IE3D Software. The return loss, VSWR, radiating efficiency, bandwidth and radiating patterns are evaluated. With IE3D simulation Software proposed antenna is designed and simulated.

Keywords—Microstrip patch, Slot, Mutual coupling Antenna array, IE3D.

I. INTRODUCTION

In the recent years with the rapid development in the modern technology communication system is used with various applications in these technologies. In the communication systems requires the low cost, low profile antenna with high gain and directivity. For these performances are not possible with single microstrip patch antenna for this phased array[2] has been designed with two or more than two element are linear, collinear or corporate feed. I have used linear feeding in my design with active element pattern array with mutual coupling effect [3]. It is necessary to consider mutual coupling in antenna array because of its important effects on results. The proposed microstrip array is design with considering active patch and passive patches in linear feed.

II. DESIGN SPECIFICATIONS

The Microstrip patch antenna parameters for rectangular geometry are calculated from the formulas given below[1].

Calculation of the Width (W)
The first step is to find the width, W of the patch at the resonant frequency using Equation 1;

\[ W = \frac{c}{2f \epsilon_r \sqrt{\epsilon_{eff} + 1}} \]  \hspace{1cm} (1)

Where
- \( \epsilon_r \) is the relative permittivity of the substrate
- \( c \) is the speed of the light in free space
- \( f_o \) is the resonant frequency

The \( \epsilon_{eff} \) effective dielectric constant equation is given by Equation (2).

\[ \epsilon_{eff} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2} \left(1 + \frac{h}{w}\right)^\frac{3}{2} \]  \hspace{1cm} (2)

The actual length of the patch is calculated by Equation 3;

\[ L = L_{eff} - 2\Delta L \]  \hspace{1cm} (3)
To measure for the fringing effects, the actual length of the patch also includes the correction factor due to fringing effect. The effective length is given by Equation 4:

$$L_{eff} = \frac{c}{2f_r \sqrt{\varepsilon_{eff}}}$$

(4)

Correction factor can be found using equation 5.

$$\Delta L = \frac{(\varepsilon_e + 0.3)(\frac{w}{h} + 0.264)}{h}$$

$$\Delta L = \frac{(\varepsilon_e - 0.258)(\frac{w}{h} + 0.8)}{h}$$

(5)

Where, $h =$ Height of the substrate.

Ground patch of the geometry is designed with the following equation 6:

Length of ground patch

$$L_g = 6h + L$$

(6.a)

Width of ground patch

$$W_g = 6h + w$$

(6.b)

The evaluated parameters are given in Table 1.

<table>
<thead>
<tr>
<th>Antenna parameters</th>
<th>Dimensions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resonant frequency $f_r$</td>
<td>3GHz</td>
</tr>
<tr>
<td>Dielectric constant $\varepsilon_r$</td>
<td>4.3</td>
</tr>
<tr>
<td>Height of Substrate (h)</td>
<td>1.5mm</td>
</tr>
<tr>
<td>Width (W)</td>
<td>30.72mm</td>
</tr>
<tr>
<td>Length (L)</td>
<td>23.74mm</td>
</tr>
<tr>
<td>Effective Length $L_{eff}$</td>
<td>25.12</td>
</tr>
<tr>
<td>Effective dielectric substrate $\varepsilon_{eff}$</td>
<td>3.96</td>
</tr>
<tr>
<td>Width of ground patch $W_g$</td>
<td>32.74mm</td>
</tr>
<tr>
<td>Length of ground patch $L_g$</td>
<td>39.72mm</td>
</tr>
<tr>
<td>Free space wavelength $\lambda$</td>
<td>100</td>
</tr>
</tbody>
</table>

The rectangular microstrip patch antenna of single element is design with the calculated parameters geometry is designed with spacing between center element and rest two elements is $\lambda /4$ ($\lambda$ is the free-space wavelength at the operating frequency). This proposed geometry is designed in symmetric pattern with linear feed elements. The concept used in proposed designed is to use active patch element in array design so that the array size will be reduced and simulation will be realized easily with limited feedings in phased array antenna design. The designed geometry is composed with single active element centered with two passive elements are feeded linearly shown in figure 2. The simple Microstrip substrate FR-4 with dielectric constant 4.3 and loss tangent 0.019 is used for my design. The radiating patch with ring shaped slot is designed and the ground plane with two parallel rectangular slots. The probe is given on centered patch at (0, -10.5), so the mutual couple and current distribution on both passive patched should be equal because of symmetrical elements. When the current on active and passive patches are same so the higher broadside gain can be achieve in phase scanning of proposed array.
III. SIMULATION AND RESULTS

The proposed design geometry with probe feeding is given at (0, -10.5), geometry of microstrip phased array antenna designed with IE3D and simulation is performed. At the resonant frequency of 3GHz the design is simulated in the frequency range of 1 to 6GHz. The simulated return losses versus frequency for the array exhibits in fig.3. The return losses at three frequency bands are -19.8dB at 1.9 GHz, -23.19 dB at 3.5 GHz, and 25.45 dB at 5.4GHz (over than -10dB in all frequency bands). The three frequency bands which cover GSM band, LTE (long term evaluation) in 4G, WiMAX and WLAN applications[6]. The total radiation efficiency is about 76% at 1.9GHz, 88% at 3.5GHz and 90% at 5.4GHz in all three bands shown in fig.4. The axial ratio is below 3dB in all given frequency range from 1 GHz to 6 GHz shown in fig.5, and VSWR in all the three frequency bands is near about 1 as shown on fig.6. Impedance matching in smith chart is shown in fig.7. The antenna peak gain is 5.8dBi and at 1.9GHz and 3.5GHz gain is 3dBi and at 5.4GHz gain is 4.4 dBi. The gain versus frequency graph is given in figure 8. The antenna directivity is 4.4 dBi at 1.9GHz, 3.8 dBi at 3.5GHz and at 5.4GHz directivity is 5.8 dBi and the peak directivity is 7.3dBi. The directivity versus frequency graph is shown in figure 9.
VI. CONCLUSION

The antenna is designed successfully and simulated with simple experimental approach to study the multiband antenna array with mutual coupling. The antenna covers the operating frequency band from 1.8GHz to 5.7GHz with good return loss characteristics. The result shows in three of the operating bands the antenna suffered in bandwidth performance which can be further optimized to improve. The antenna exhibited good impedance matching in all the operating bands and attained a peak gain of 5.8 dBi. The radiation characteristics resulted with a directivity of 7.4dBi without sidelobes and possess broad beamwidth to provide good coverage in desired directions for communication applications. The attained bands of operation make the antenna most suitable for applications such as GSM, WLAN, WIMAX communications.

References